

AD-775 615

CATAPULT FATIGUE TEST OF THE MODEL
C-2A AIRPLANE

Edward F. Kautz

Naval Air Development Center
Warminster, Pennsylvania

31 December 1973

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UNCLASSIFIED

Security Classification

AD-775615

DOCUMENT CONTROL DATA - R & D

Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified

1. ORIGINATING ACTIVITY (Corporate author) Naval Air Development Center Air Vehicle Technology Department Warminster, Penna. 18974		2a. REPORT SECURITY CLASSIFICATION UNCLASSIFIED	
3. REPORT TITLE CATAPULT FATIGUE TEST OF THE MODEL C-2A AIRPLANE		2b. GROUP	
4. DESCRIPTIVE NOTES (Type of report and inclusive dates) FINAL REPORT			
5. AUTHOR(S) (First name, middle initial, last name) EDWARD F. KAUTZ			
6. REPORT DATE 31 December 1973		7a. TOTAL NO. OF PAGES 33	7b. NO. OF REFS 2
8a. CONTRACT OR GRANT NO.		9a. ORIGINATOR'S REPORT NUMBER(S) NADC-73179-30	
b. PROJECT NO. AIRTASK NO. A510-5103/001-4/2510-000002		9b. OTHER REPORT NO.'S (Any other numbers that may be assigned this report)	
c. WORK UNIT MA501			
d.			
10. DISTRIBUTION STATEMENT APPROVED FOR PUBLIC RELEASE; DISTRIBUTION UNLIMITED			
11. SUPPLEMENTARY NOTES		12. SPONSORING MILITARY ACTIVITY Naval Air Systems Command Department of the Navy Washington, D. C. 20361	
13. ABSTRACT A laboratory fatigue test was performed on a C-2A airframe to determine whether the airframe could sustain the effects of 3000 catapult launches. A total of 6000 catapult launch cycles were applied to the airframe with no structural failures. With a test scatter factor of 2, the 6000 test cycles are equivalent to 3000 service catapult launches.			

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14 KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
Airframe Cargo Aircraft Fatigue (materials) Fatigue Tests Fuselages Military Aircraft Shipboard Landing Stresses Structural Parts						

DD FORM 1473 (BACK)
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DEPARTMENT OF THE NAVY
NAVAL AIR DEVELOPMENT CENTER
WARMINSTER, PA. 18974

AIR VEHICLE TECHNOLOGY DEPT.

REPORT NO. FADC-73179-30

31 DECEMBER 1973

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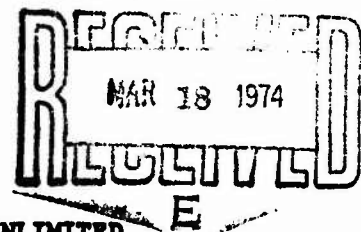
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Reported by: Edward F. Kautz
EDWARD F. KAUTZ
Structures Division

Reviewed by: M. E. Soennichsen
M. E. SOENNICHSEN
Structures Division

Released by: C. G. Weeber
C. G. WEEBER, Supt.
Structures Division



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S U M M A R Y

A laboratory fatigue test was performed on a C-2A airframe to determine whether the airframe could sustain the effects of 3000 catapult launches. A total of 6000 catapult launch cycles were applied to the airframe with no structural failures. With a test scatter factor of 2, the 6000 test cycles are equivalent to 3000 service catapult launches.

INTRODUCTION

The C-2A airplane, which is of the nose tow catapult configuration, was certified for 1000 catapult launches as a result of nose gear catapult fatigue tests performed by the Grumman Aerospace Corporation (GAC) in 1966. Service usage records indicate, however, that 1000 catapult launches will be grossly insufficient to satisfy projected operational requirements for this model airplane. A more realistic requirement is the capability to sustain 3000 catapult launches.

Since the catapult fatigue life of the nose landing gear had already been established by the GAC tests, the results of which are presented in reference (a), the objectives of this test program were to determine the capacity of the C-2A airframe to sustain 3000 catapult launches and to determine any structural modifications necessary to achieve this life.

DESCRIPTION OF TEST SPECIMEN

The test specimen was a C-2A fuselage and wing center section that had been used by GAC for catapult and arrested landing static tests and for drop tests. During the final drop test the fuselage broke into two pieces just forward of the wing. The aft section of this fuselage was used by the NAVAIRDEVCON for an arrested landing fatigue test. The results of this test are presented in reference (b). For this catapult fatigue test the forward and aft sections of the fuselage were joined with a splice that extended from approximately fuselage station (FS) 195 to FS 282. The test specimen is shown in Figure 1.

The catapult forces on the nose gear tow link are transmitted by the shock strut and drag brace to support fittings attached to the fuselage. The shock strut support fittings located at FS 66.65 provide vertical and lateral stability while fore and aft stability is provided by the drag brace support fittings located at FS 130.10.

A dummy nose landing gear was used in this test instead of an actual nose gear since, as previously mentioned, the catapult fatigue life of the nose gear has already been established.

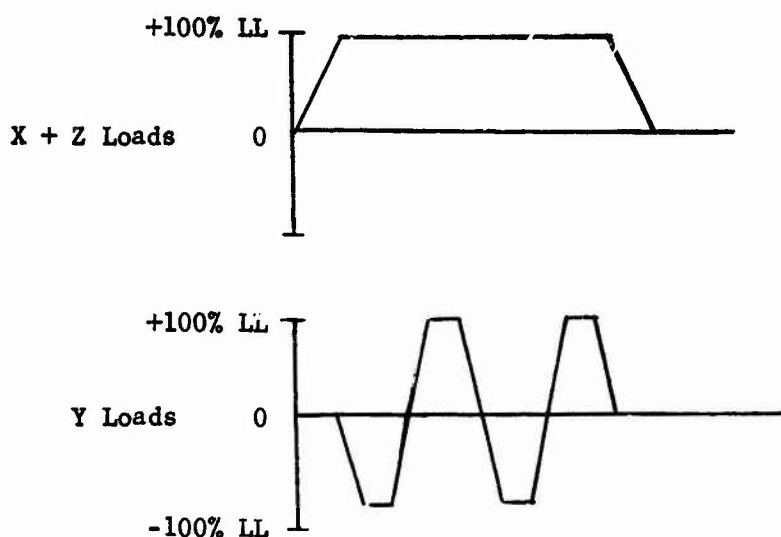
The dummy gear provided the correct distribution of loads to the shock strut support fittings and drag brace support fittings.

TEST PROGRAM

To demonstrate the capability to withstand the effects of 3000 catapult launches in service, using a scatter factor of 2, a total of 6000 catapult launches were simulated during the test.

The locations and magnitudes of applied loads and reactions are shown in Appendix A, Figure A-2 and Table A-1. The loads correspond to GAC condition 11Ca catapulting start of Run II for a catapulting design gross weight of 54,354 pounds.

Each test load cycle, representing 1 catapult launch, was applied according to the requirements of paragraph 3.5.3.1 of MIL-A-8867. A graphical representation of the load cycle is shown below:



TEST METHOD

The test specimen was positioned with the FRL parallel to and 134 inches above the floor and the plane of symmetry perpendicular to the floor.

The specimen was supported by dummy main landing gear which reacted loads in the vertical, axial, and lateral directions.

Test loads were applied to the airplane with hydraulic actuators which were part of an electro-hydraulic, servo-controlled closed loop loading system. Independent control of each actuator was provided by individual servo valves and servo controllers. Load direction and phase relationships for the 14 actuators were provided by a multichannel programmer.

Loads were monitored on chart recorders and a multichannel bar-graph video display, all of which provided overload protection. Additional and independent overload protection was provided by error detectors

on each servo controller and stroke limit switches on each actuator. Triggering any overload system would immediately dump hydraulic pressure at each actuator and at the hydraulic power supply.

The X and Z loads on the dummy nose gear were applied as a resultant using a single actuator. The side loads were applied with a separate actuator. The catapult loading system is shown in Figure 2. Overall views of the entire test setup are shown in Figures 3 and 4.

RESULTS

A total of 6000 catapult launch cycles were applied to the test specimen with no indications of structural failure.

CONCLUSIONS

The C-2A airframe is capable of sustaining the effects of 3000 catapult launches without structural modifications.

RECOMMENDATIONS

It is recommended that the limit of 1000 catapult launches currently imposed on the C-2A airframe be increased to 3000. This recommendation applies only to the airframe and not to the nose landing gear which, according to the results of previous tests (reference a) has a catapult fatigue life substantially less than 3000 launches.

ACKNOWLEDGMENTS

The author wishes to acknowledge the valuable assistance during the test program of Messrs. R. Vining, H. Lystad, L. Berman and V. Catone of the Naval Air Development Center.

REFERENCES

(a) GAC Report No. 3839.12A, Results of Nose Gear Catapult Fatigue Tests, dated 12 September 1966.

(b) NADC Report NADC-ST-7111, Arrested Landing Fatigue Test of Model C-2A Airplane dated 30 June 1971.

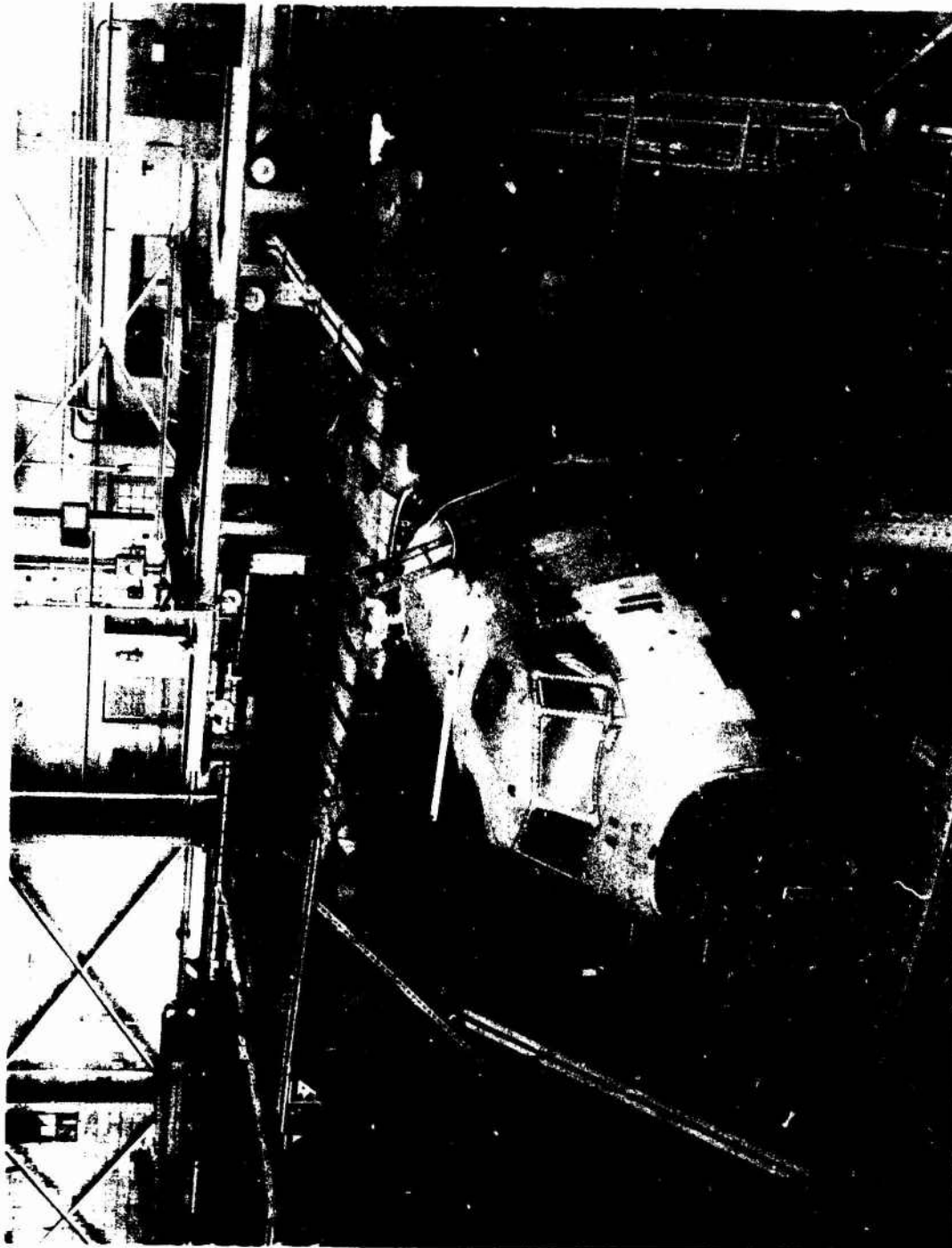


Figure 1. C-2A Test Specimen

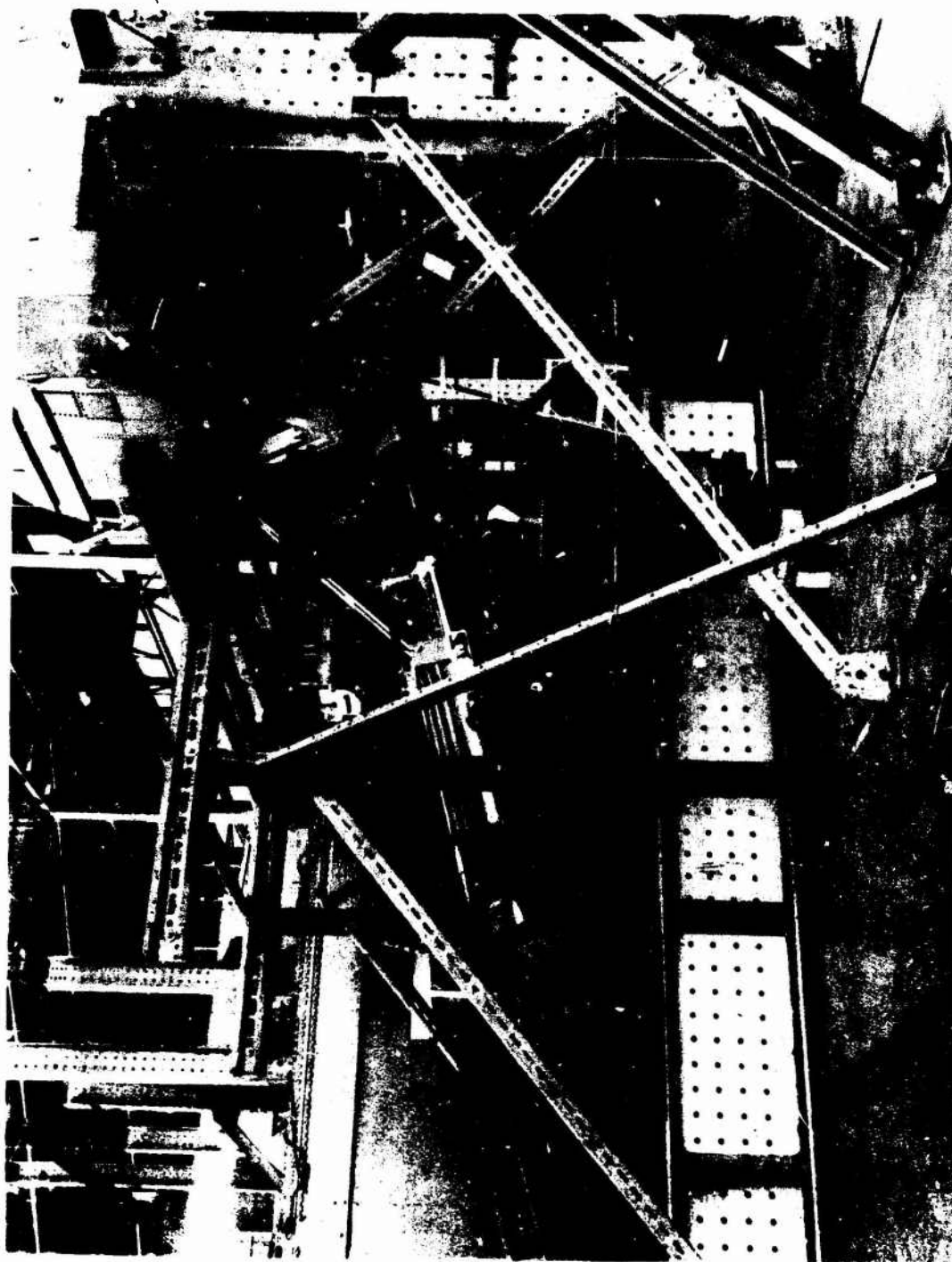


Figure 2. Dummy Nose Gear Loading Arrangement



Figure 3. Catapult Test Setup



Figure 4. Catapult Test Setup

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APPENDIX A
TEST DATA FOR CATAPULT FATIGUE TEST OF THE MODEL C-2A AIRPLANE

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SYMBOLS

All symbols used in this appendix and in the test of the report are defined below:

FS fuselage station

FRL fuselage reference line

LL limit load = 2/3 design
ultimate load

Re resultant load

SIGN CONVENTION

The following sign convention is used: Distances and forces are positive when they are up, aft and to the left with respect to the reference axes. (See Figure A-1).

Positive bending moments produce compression in the top surface and left side of the fuselage.

Positive vertical shear results when the positive vertical loads are summed from a station of greater magnitude to one of lesser magnitude. Positive lateral shear results when the positive lateral loads are summed from a station of greater magnitude to one of lesser magnitude.

Positive torsion about the FRL results when a station of higher magnitude rotates clockwise in relation to a station of lower magnitude when viewed from aft.

REFERENCE AXES

- X - axis: Lies in the plane of symmetry 100 inches below and parallel to the FRL.
- Y - axis: Perpendicular to the plane of symmetry through the X - axis at FS 0.
- Z - axis: Perpendicular to the X-Y plane through the intersection of the X and Y axes.

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BASIC DATA

Catapulting design gross weight 54,354 pounds

Catapulting test condition (Reference a) GAC condition
11Ca catapulting
start of run II

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TEST LOADS

The magnitudes of the test loads are listed in Table A-1. Comparison of the design curves (from reference b) and the test curves are shown in Figures A-3 through A-8. The balance diagram showing the locations of applied loads and reactions is shown in Figure A-2.

TEST SPECTRUM

The test spectrum is the catapult spectrum of paragraph 3.5.3.1 of MIL-A-8867.

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REFERENCES

(a) GAC report No. 3803.3A, Ground Loading Conditions, dated 1 September 1963.

(b) GAC report No. 3808.1A, Fuselage Net Loads, dated 27 August 1964.

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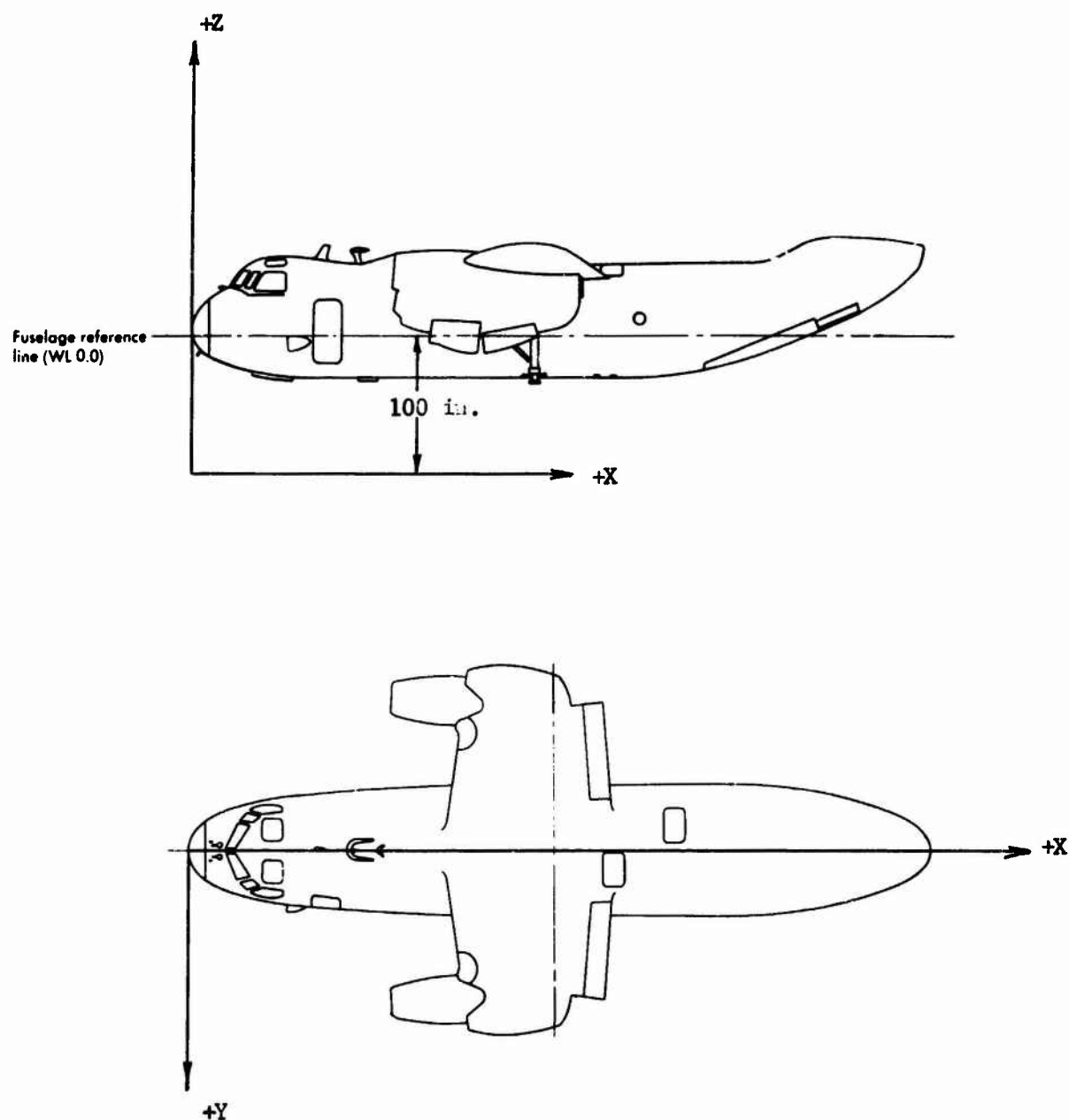
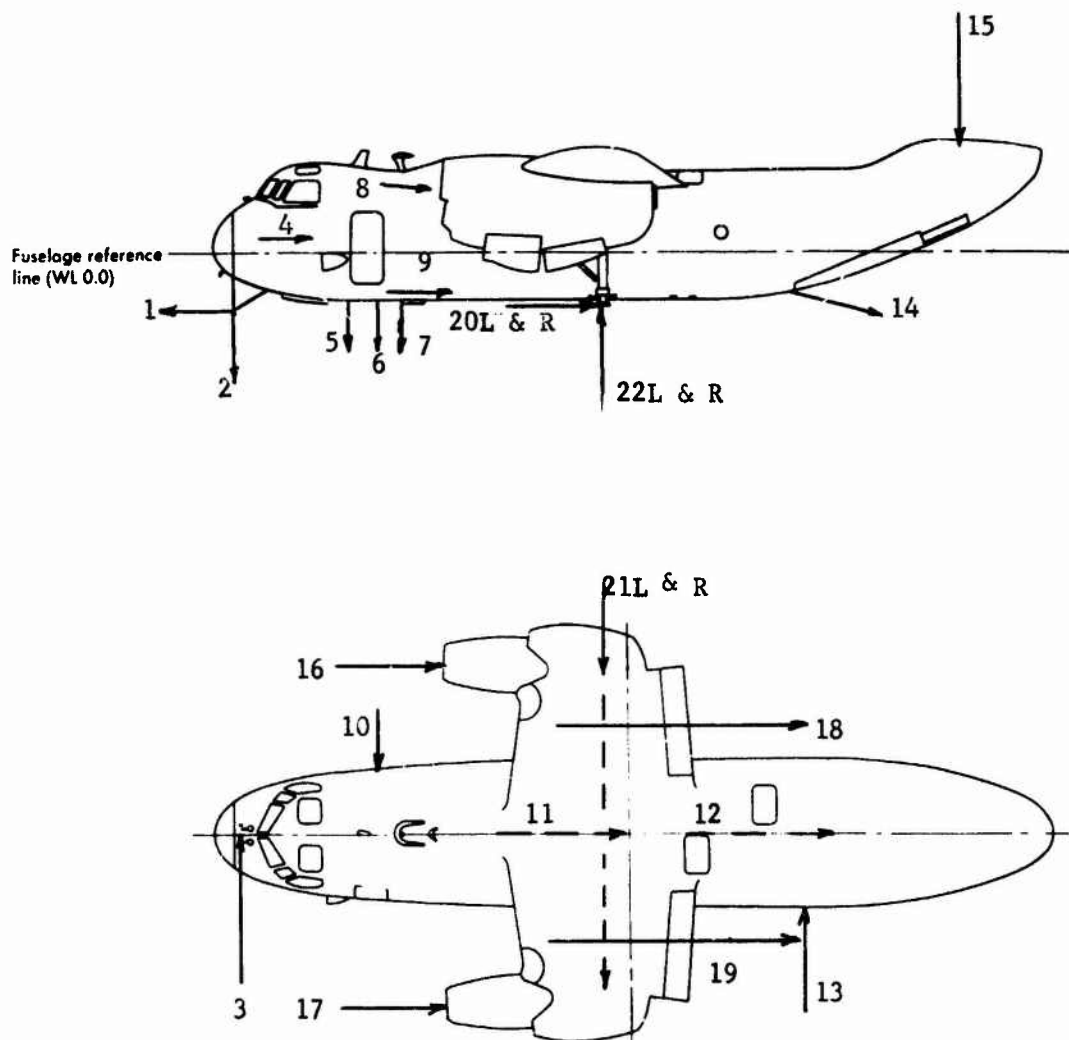


FIGURE A-1 REFERENCE AXES AND SIGN CONVENTION



Note: The numbers correspond to the load point numbers of table A-1.

FIGURE A-2 BALANCE DIAGRAM

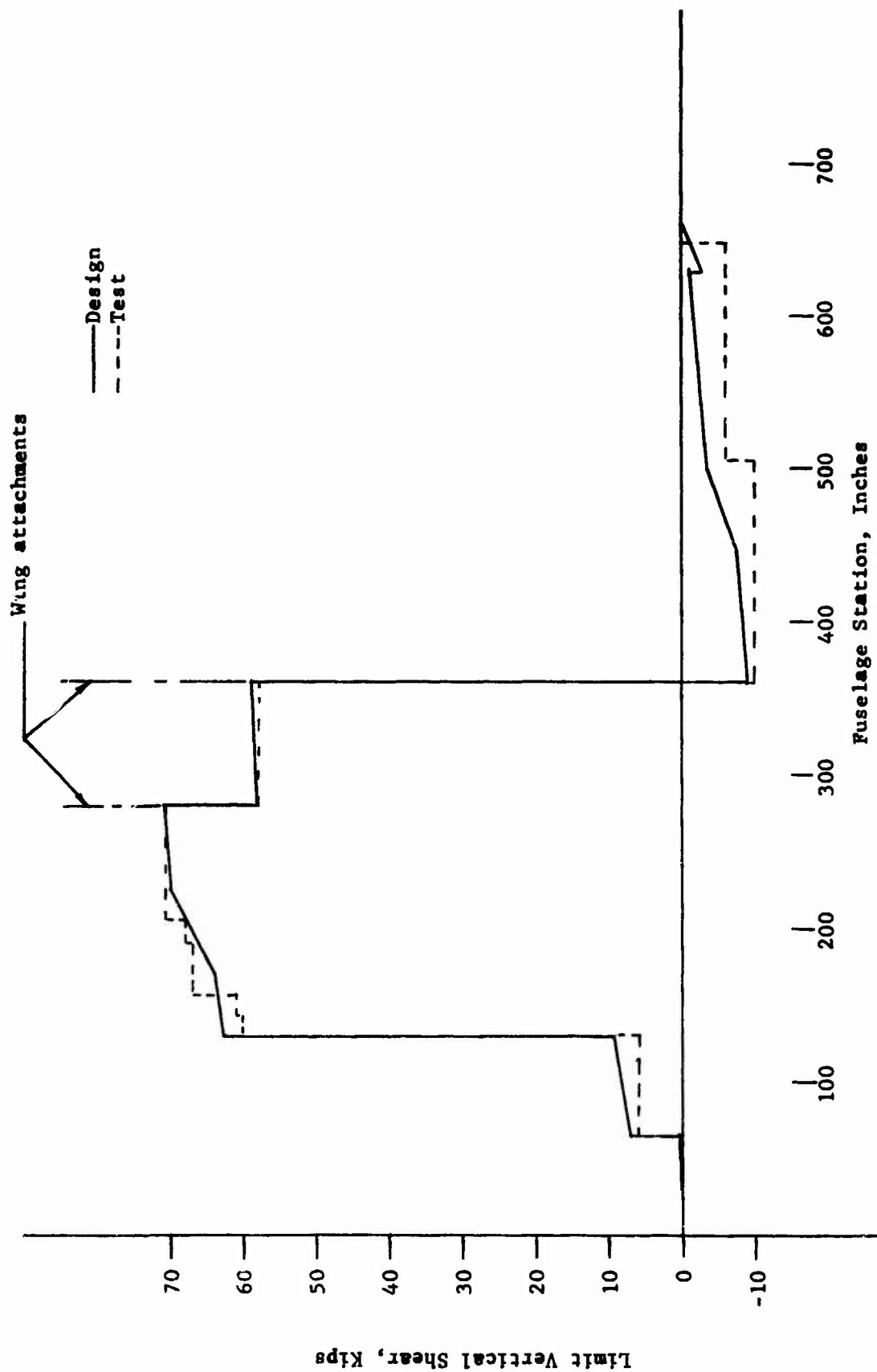


FIGURE A-3 FUSELAGE VERTICAL SHEAR DISTRIBUTION

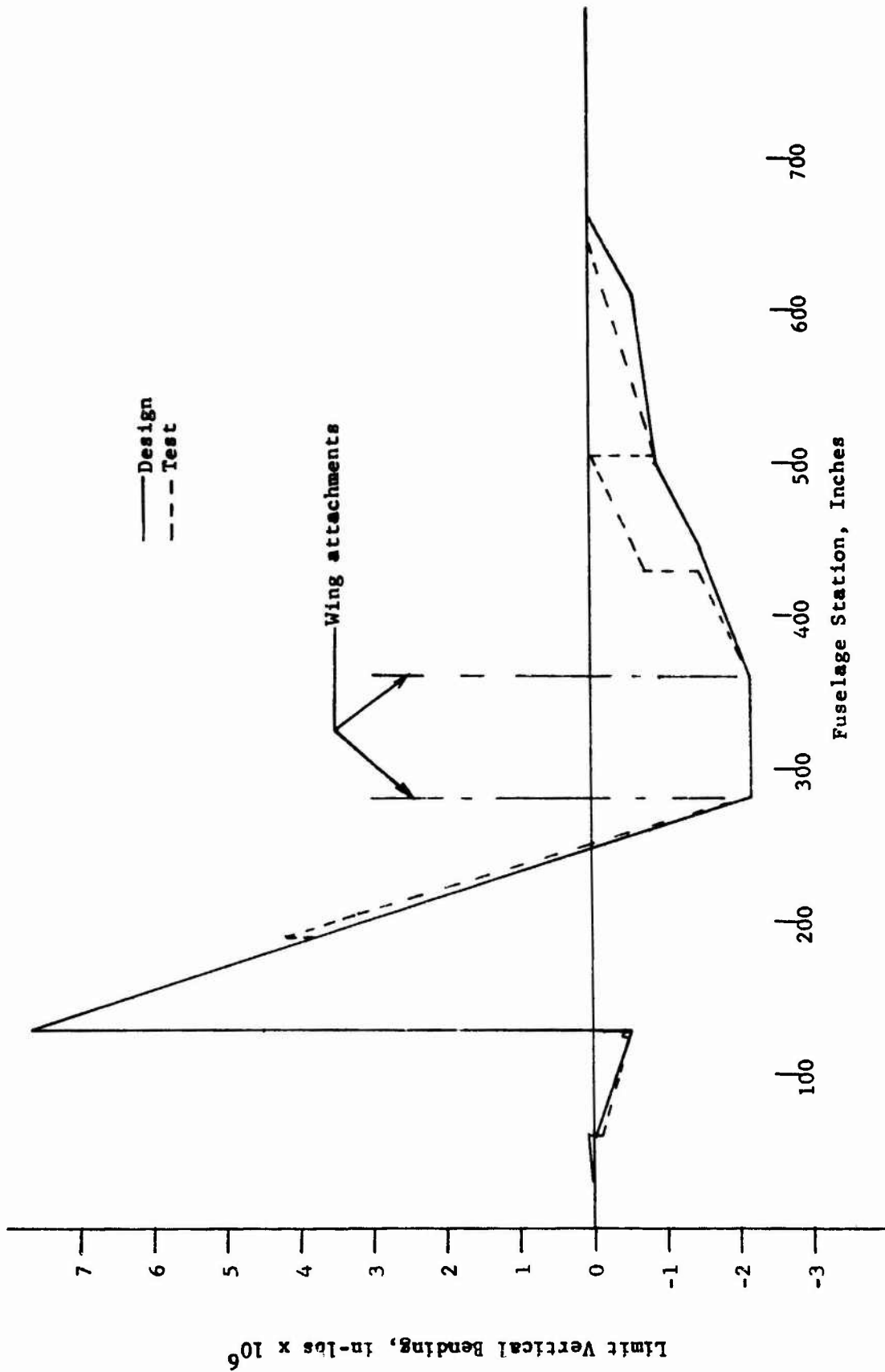


FIGURE A-4 FUSELAGE VERTICAL BENDING MOMENT DISTRIBUTION

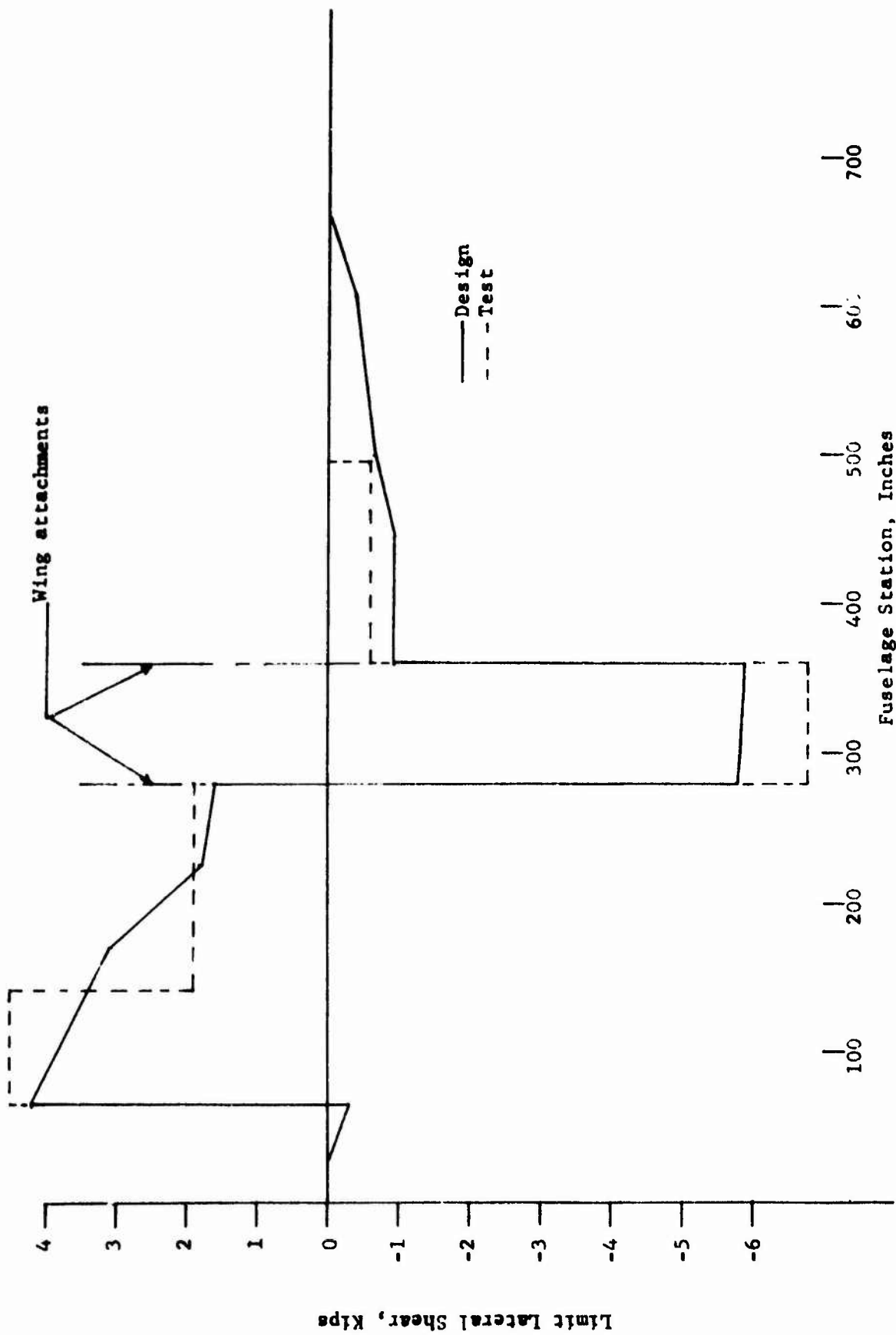


FIGURE A-5 FUSELAGE LATERAL SHEAR DISTRIBUTION

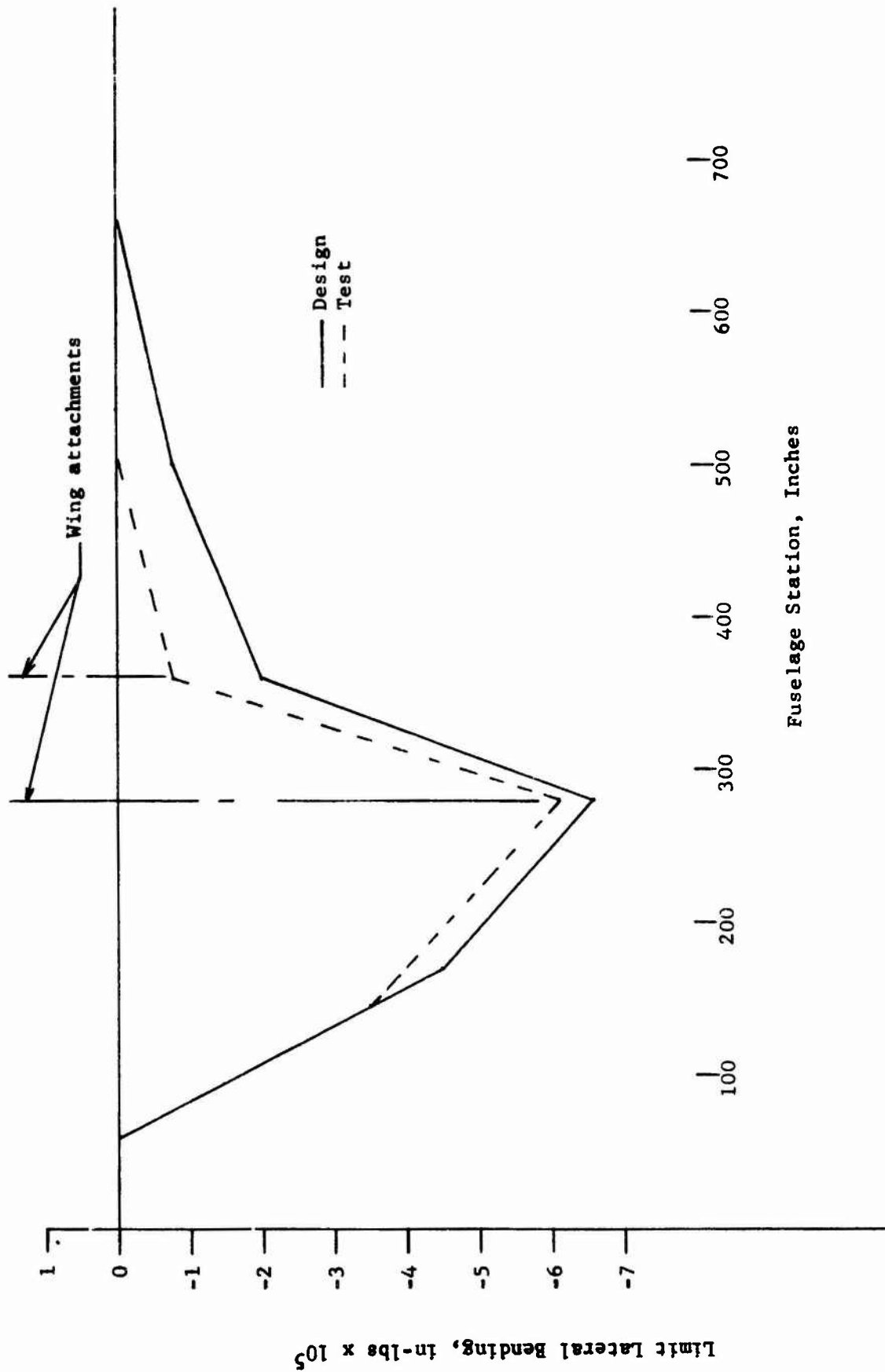


FIGURE A-6 FUSELAGE LATERAL BENDING MOMENT DISTRIBUTION

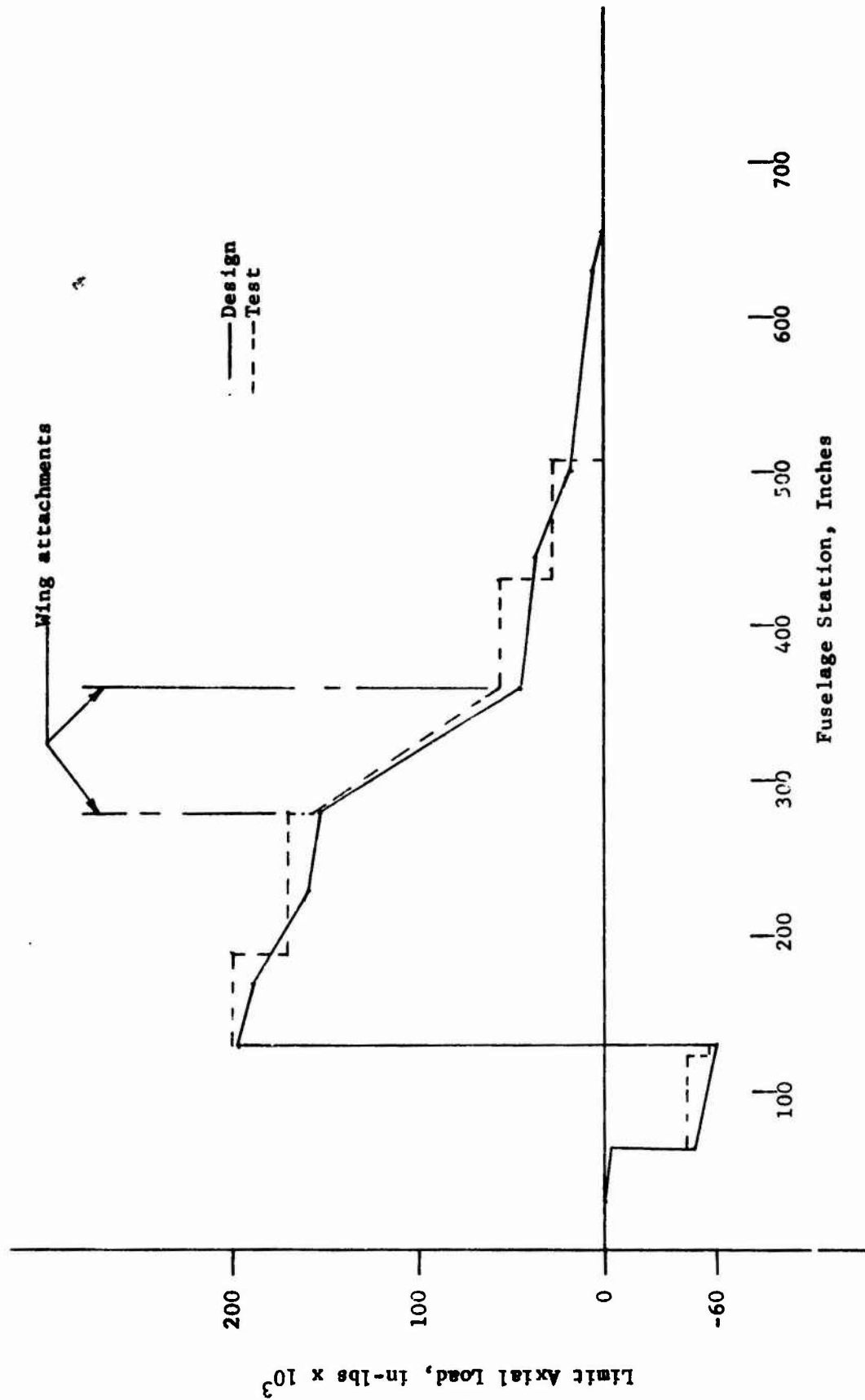


FIGURE A-7 FUSELAGE AXIAL LOAD DISTRIBUTION

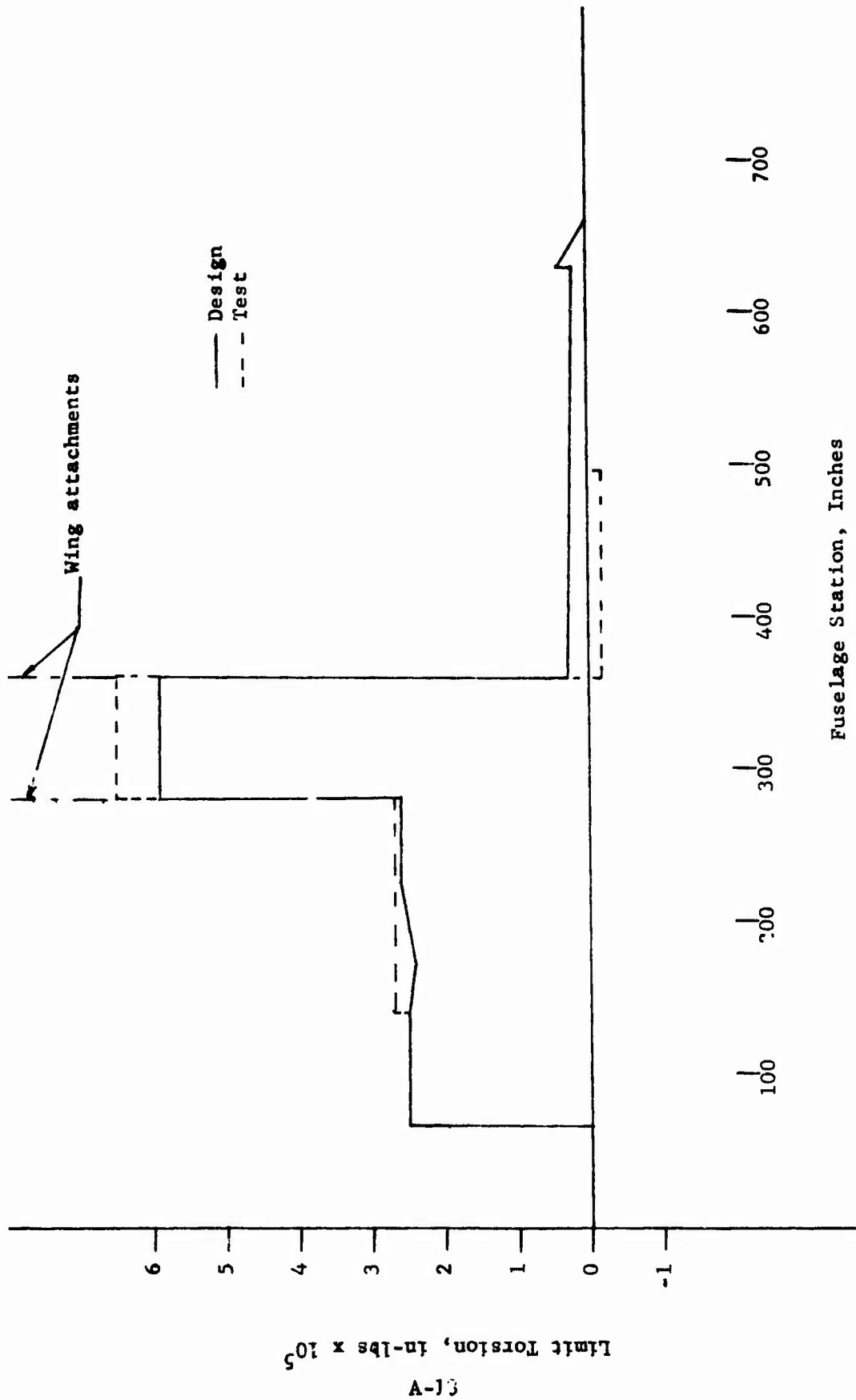


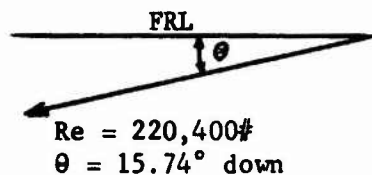
FIGURE A-8 FUSELAGE TORSIONAL MOMENT DISTRIBUTION

TABLE A-1-TEST LOADS-CATAPULT CONDITION 11Ca
SIDE LOAD RIGHT

Load Point	Location, Inches			Applied Loads		
	X	Y	Z	X	Y	Z
1. Dummy Nose Gear	61.69	0	44.75	-212133	0	0
2. Dummy Nose Gear	61.69	0	44.75	0	-4493	0
3. Dummy Nose Gear	61.69	0	44.75	0	0	-59800
4. Cockpit Floor	125.00	0	109.00	+10666	0	0
5. Fwd Fuselage	143.75	0	100.00	0	0	-1200
6. Fwd Fuselage	157.50	0	100.00	0	0	-5960
7. Fwd Fuselage	205.50	0	100.00	0	0	-2500
8. Fwd Fuselage	190.50	0	153.50	+14822	0	-1332
9. Fwd Fuselage	190.50	0	75.00	+16016	0	0
10. Fwd Fuselage	143.75	0	108.65	0	+2620	0
11. Cargo Cage	282.50	0	96.36	+13668	0	0
12. Cargo Cage	430.50	0	128.00	+25733	0	0
13. Aft Fuselage	495.50	0	67.00	0	-578	0
14. Arresting Hook	507.50	0	72.00	+29569	0	-3670
15. Tail	647.00	0	100.00	0	0	-6132
16. Right Engine Mt	365.19	-126.26	141.64	+12649	0	0
17. Left Engine Mt	365.19	126.26	141.64	+12649	0	0
18. Right Wing	365.19	-73.31	155.30	+34666	0	0
19. Left Wing	365.19	73.31	155.30	+34666	0	0
Reaction Loads						
20L. L. Main Gear	349.58	126.26	76.84	+6165	0	0
20R. R. Main Gear	349.58	-126.26	76.84	+862	0	0
21L. L. Main Gear	349.58	126.26	76.84	0	+1225	0
21R. R. Main Gear	349.58	-126.26	76.84	0	+1225	0
22L. L. Main Gear	349.58	126.26	76.84	0	0	+41220
22R. R. Main Gear	349.58	-126.26	76.84	0	0	+39374

Notes:

- The X and Z loads applied to the dummy nose gear will be applied as the following resultant load:



This load is the resultant of the catapult tow link loads and wheel axle loads.

- When the nose gear side load is applied to the left the loads at load points 2,10,13,21L and 21R reverse direction.